

Flame Retardant Alternatives

Triphenyl Phosphate

Hazard Review

Triphenyl Phosphate:
Existing Data Summary Table – Human Health Endpoints

✓ = Endpoint characterized by existing data * = Data available but not adequate ✗ = Endpoint not applicable

As noted in this key, a check mark indicates that an endpoint was adequately characterized by existing studies. It does not indicate a positive or negative result for that particular endpoint.

<i>Acute Toxicity</i>	
Oral	✓
Dermal	✓
Inhalation	*
Eye irritation	✓
Dermal irritation	✓
Skin sensitization	✓
<i>Subchronic Toxicity</i>	
28-Day oral	*
90-Day oral	*
Combined repeated dose with reproduction/developmental toxicity screen	
21/28-Day dermal	*
90-Day dermal	
90-Day inhalation	
<i>Reproductive Toxicity</i>	
Reproduction/developmental toxicity screen	*
Combined repeated dose with reproduction/developmental toxicity screen	
Reproduction and fertility effects	

<i>Developmental Toxicity</i>	
Reproduction/developmental toxicity screen	
Combined repeated dose with reproduction/developmental toxicity screen	
Prenatal developmental	✓
<i>Chronic Toxicity</i>	
Chronic toxicity (two species)	
Combined chronic toxicity/carcinogenicity	
<i>Carcinogenicity</i>	
Carcinogenicity (rat and mouse)	
Combined chronic toxicity/carcinogenicity	

<i>Neurotoxicity</i>	
Acute and 28-day delayed neurotoxicity of organophosphorus substances (hen)	✓
Neurotoxicity screening battery (adult)	✓
Developmental neurotoxicity	
Additional neurotoxicity studies	✗
<i>Immunotoxicity</i>	
Immunotoxicity	✓
<i>Genotoxicity</i>	
Gene mutation in vitro	✓
Gene mutation in vivo	
Chromosomal aberrations in vitro	
Chromosomal aberrations in vivo	
DNA damage and repair	
Other	✓

Triphenyl Phosphate:
Existing Data Summary Table – Properties, Fate, and Ecotoxicity

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P/Chem Properties	
Water solubility	✓
Octanol/water partition coefficient	✓
Oxidation/reduction	
Melting point	✓
Boiling point	✓
Vapor pressure	✓
Odor	✓
Oxidation/reduction chemical incompatibility	
Flammability	✓
Explosivity	
Corrosion characteristics	
pH	
UV/visible absorption	✓
Viscosity	
Density/relative density/bulk density	✓
Dissociation constant in water	✗
Henry's Law constant	✓

Environmental Fate	
<i>Bioconcentration</i>	
Fish	✓
Daphnids	
Green algae	
Oysters	
Earthworms	
Metabolism in fish	*
<i>Degradation and Transport</i>	
Photolysis, atmosphere	
Photolysis, water	✓
Photolysis in soil	
Aerobic biodegradation	✓
Anaerobic biodegradation	
Porous pot test	
Pyrolysis	*
Hydrolysis as a function of pH	✓
Sediment/water biodegradation	✓
Soil biodegradation w/ product identification	✓
Indirect photolysis in water	
Sediment/soil adsorption/desorption	✓

Ecotoxicity	
<i>Aquatic Toxicity</i>	
Fish acute LC50	✓
Daphnia acute EC50	✓
Mysid shrimp acute LC50	*
Green algae EC50, NOAEC, LOAEC	✓
Fish chronic NOAEL, LOAEC	✓
Daphnia chronic NOAEC, LOAEC	
Mysid shrimp chronic NOAEC, LOAEC	
Sediment organisms	*
<i>Terrestrial Organism Toxicity</i>	
Bird LD50 (two species)	
Bird LC50 (two species)	
Bird reproduction	
Earthworm subchronic EC50, LC50, NOAEC, LOAEC	

Chemical Identity

Triphenyl phosphate
CAS 115-86-6
MF $C_{18}H_{15}O_4P$
MW 326.29
SMILES c1ccccc1OP(=O)(Oc2ccccc2)Oc3ccccc3

Human Health Endpoints

ACUTE TOXICITY

Acute Oral Toxicity (OPPTS Harmonized Guideline 870.1100; OECD Guidelines 425, 420, 423, 401).

Conclusion:

The available acute oral toxicity data were judged adequate to meet the endpoint.

Basis for Conclusion:

Several acute oral lethality studies were available in a variety of species: rats, mice, rabbits, guinea pigs, and hens. These studies were from the older (pre 1980) literature, and do not fully conform to OPPTS or OECD guidelines, but together may be adequate to support the evaluation of acute oral toxicity. The toxic potency of TPP tended to be somewhat lower when it was administered in aqueous vehicle (usually as a suspension) than when administered in oil. Deaths generally did not occur following administration in aqueous vehicle ($LD_{50} > 5,000$ - $20,000$ mg/kg), and were seen at relatively high doses ($LD_{50} = 10,800$ mg/kg) from administration in oil. Two of the better studies in the preferred species (rat), one using an aqueous vehicle and the other using an oil vehicle, and one each in mice and rabbits using an aqueous vehicle, are summarized below as the critical studies.

Critical Studies:

Type: Acute oral limit test

Species, strain, sex, number: Rat, Wistar, 5 male and 5 female

Dose: 20,000 mg/kg

Purity: Not reported, Monsanto commercial TPP

Vehicle: Water: 25% aqueous "solution"

Method: Similar to limit test, but higher dose; 24-hour fasting period prior to dosing; 14-day post-dosing observation period; observations limited to mortality and necropsy

Results: No deaths, therefore $LD_{50} > 20,000$ mg/kg. Necropsy revealed sporadic visceral hemorrhages.

Reference: Food and Drug Research Labs, 1976

Type: Acute oral LD50

Species, strain, sex, number: Rat, Sprague-Dawley, male and female, number not specified

Dose: Up to 15,800 mg/kg

Purity: GC-verified, but not specifically reported

Vehicle: Corn oil

Observation period: 14 days post dosing

Method: LD50 calculated according to DeBeer (1945); not specified whether fed or fasted at time of dosing; 14-day post-exposure observation period; mortality only

Results: LD50 = 10,800 mg/kg; actual mortality data not reported

Reference: Johannsen et al., 1977

Type: Acute oral limit test

Species, strain, sex, number: Mouse, strain not specified, male and female, 5 total/dose

Doses: 2,500 and 5,000 mg/kg

Purity: Not specified

Vehicle: Emulsion in aqueous gum acacia

Method: Similar to limit test; not specified whether fed or fasted at time of dosing; 8-day observation period; observations limited to mortality and overt signs

Results: No deaths at either dose; therefore, LD50 >5,000 mg/kg; slight stupor

Reference: Ciba-Geigy Ltd., 1954

Type: Acute oral limit test

Species, strain, sex, number: Rabbit, strain and sex not specified, 1/dose

Purity: Technical grade TPP

Doses: 3,000 and 5,000 mg/kg

Vehicle: Suspended in aqueous gum acacia

Method: Preliminary limit test, observation was for “several days”, observations limited to clinical signs and mortality

Results: Neither rabbit died, indicating LD >5,000 mg/kg; both had diarrhea

Reference: Dow Biochemical Research, 1934

Additional Studies and Information:

Other studies that were of lesser quality or were reported in less detail are generally consistent with the above studies (Houghton EF & Company, no date; Kettering Lab, 1945; Smith et al., 1932; Sutton et al., 1960).

Specific organ toxicity was generally not observed in the studies that include gross pathological examinations. Some signs possibly indicative of neurotoxicity (lassitude incoordination, tremors, or weakness) were observed in a few studies (Ciba-Geigy Ltd. 1954; Kettering Lab, 1945; Smith et al., 1932). It has been suggested that at the very high doses employed in these acute toxicity studies, even small amounts of impurities could be responsible for the apparent neurotoxicity, which has not been seen with purified TPP (see section on neurological effects), or that the signs may have been secondary to other effects.

Acute Dermal Toxicity (OPPTS Harmonized Guideline 870.1200; OECD Guideline 402)

Conclusion:

The available acute dermal toxicity data were judged adequate to meet the endpoint.

Basis for Conclusion:

The available studies predate the preferred study guidelines, and lack details including purity and discussion of necropsy results, but together indicate a low order of toxicity ($LD_{50} > 7,900$ -10,000 mg/kg), consistent with the acute oral studies.

Type: Acute dermal toxicity

Species, strain, sex, number: Rabbit, albino, sex not specified, 10

Dose: 10,000 mg/kg

Purity: No data, commercial product provided by Monsanto, white flakes

Vehicle: Not reported, but the concurrent acute oral study used water

Method: U.S. Federal Hazardous Substances Act Regulations study guideline 16 CFR 1500.40; 5 rabbits tested with intact skin and 5 with abraded skin; 14-day observation period

Results: Mortality after 14 days 0/5 intact, 0/5 abraded. Therefore, $LD_{50} > 10,000$ mg/kg.

Reference: Food and Drug Research Labs, 1976

Type: Acute dermal toxicity

Species, strain, sex, number: Rabbit, New Zealand albino, sex and number not specified

Dose: Highest dose = 7,900 mg/kg

Purity: No data, prepared from pure phenol

Vehicle: None ("undiluted")

Method: Intact skin, occlusive dressing, test material washed off after 24 hours, 14-day observation period. Necropsy.

Results: No deaths; therefore, $LD_{50} > 7,900$ mg/kg; necropsy results not discussed.

Reference: Johanssen et al., 1977

Acute Inhalation Toxicity (OPPTS Harmonized Guideline 870.1300 (OECD Guideline 403)

Conclusion:

The available acute inhalation toxicity data were judged inadequate to meet the endpoint, unless data regarding particle size in the TPP powder study are provided.

Basis for Conclusion:

The available studies on TPP predate the preferred guidelines, but the study using TPP powder (Food and Drug Research Labs, 1976) was reported to be conducted according to a guideline that was relevant at the time. The duration was shorter than currently recommended and the

concentration was much higher, but no signs of toxicity and no deaths were observed. Analysis of particle size, however, was not mentioned, so it is not known whether the size was respirable. Necropsies apparently were not performed. The other available study, on TPP vapor (Sutton et al., 1960), was conducted at an exposure level lower than recommended for a limit test, the observation period was inadequate, and it appears that the chamber was a closed chamber, which is not according to guideline.

Type: Acute inhalation toxicity

Species, strain, sex, number: Rat, Wistar, 5 males and 5 females

Doses: 200 mg/L (nominal); administered as a powder; particle size not reported

Purity: No data, commercial product provided by Monsanto, white flakes

Vehicle: None

Duration: 1 hour

Method: 16 CFR 1500.3; 300 mL chamber with air flow of 5 L/minute. Observation period = 14 days. Observed daily for signs of toxicity and for mortality.

Results: Mortality after 14 days 0/5 males, 0/5 females; no overt signs of toxicity

Reference: Food and Drug Research Labs, 1976

Type: Acute inhalation toxicity

Species, strain, sex, number: Mouse, Carworth Farms CF 1, male

Doses, duration, number: 363 mg/m³ (6 hours exposure, 5 mice) and 757 mg/m³ (2 and 4 hours exposure, 7 mice/duration)

Purity: Practical Grade Eastman

Vehicle: None

Method: The mice were exposed to TPP vapor in a battery jar following generation of the vapor by flowing preheated air through molten TPP at 175-180°C. Observation period = 24 hours. The mice were observed for signs of cholinergic toxicity and blood cholinesterase was measured at termination.

Results: No overt signs of toxicity; cholinesterase determinations not considered valid because controls did not appear to have been sham exposed.

Reference: Sutton et al., 1960

Acute Eye Irritation (OPPTS Harmonized Guideline 870.2400; OECD Guideline 405)

Conclusion:

The available eye irritation data were judged adequate to meet the endpoint.

Basis for Conclusion:

Two reasonably adequate studies report similar results in rabbits: mild reversible irritation primarily of the conjunctiva. The studies are summarized below.

Type: Acute eye irritation

Species, strain, sex, number: Rabbit, albino, sex not specified; 9

Doses: 100 mg

Purity: No data, commercial product provided by Monsanto, white flakes

Vehicle: Not reported

Method: Patterned after U.S. Federal Hazardous Substances Act Regulations study guideline 16 CFR 1500.42, except 6 rabbits—eyes not washed after instillation of TPP, 3 rabbits—eyes washed 4 seconds following instillation of TPP; eyes examined at 24, 48, and 72 hours, and 7 days after instillation of TPP.

Results: Mild conjunctival effects (slight redness 6/6, slight discharge 4/6) at 24 hours in the eyes that were not washed out, which cleared by 72 hours; no effects in eyes that had been washed out (incidence 0/3).

Reference: Food and Drug Research Labs, 1976

Type: Acute eye irritation

Species, strain, sex, number: Rabbit, New Zealand, 3 males and 3 females

Doses: 100 mg

Purity: No data, commercial product provided by Monsanto, white flakes

Vehicle: None

Method: Patterned after U.S. Federal Hazardous Substances Labeling Act Section 191.12 (February 1965). Eyes of 3 (of the 6) rabbits were washed out 30 seconds following instillation of TPP; eyes examined at 1, 24, 48, and 72 hours and 6 days after TPP instillation.

Results: Mild conjunctival effects (slight redness 6/6) at 24 hours in all exposed eyes, which cleared in all but 1 (unwashed) eye by 72 hours; and in that eye by 6 days. Slight corneal opacity was seen in one unwashed eye at 24 hours, which cleared by 48 hours.

Reference: Ciba-Geigy Pharmaceuticals Division, 1983a

Acute Dermal Irritation (OPPTS Harmonized Guideline 870.2500; OECD Guideline 404)

Conclusion:

The available dermal irritation data were judged adequate to meet the endpoint.

Basis for Conclusion:

Two reasonably adequate studies, patterned after guidelines in effect at the time, provide similar results, indicating that TPP was not a skin irritant in rabbits. Additional studies provide support. The studies are summarized below.

Critical Studies:

Type: Acute dermal irritation

Species, strain, sex, number: Rabbit, albino, sex not specified, 6

Doses: 500 mg

Purity: No data, commercial product provided by Monsanto, white flakes

Vehicle: Not reported, but acute oral study used water

Method: Patterned after U.S. Federal Hazardous Substances Act Regulations study guideline 16 CFR 1500.41; shaved back, each rabbit tested on intact and abraded skin, semiocclusive dressing removed after 24 hours, observations at 24 and 72 hours.

Results: No erythema or edema on intact or abraded skin in any of the 6 rabbits.

Reference: Food and Drug Research Labs, 1976

Type: Acute dermal irritation

Species, strain, sex, number: Rabbit, New Zealand, 3 males and 3 females

Doses: 1.0 mL of suspension of 10,000 mg/20 mL = 500 mg

Purity: No data, white flakes

Vehicle: 50% aqueous solution of polyethylene glycol

Method: U.S. Federal Hazardous Substances Labeling Act Section 191.12 (February 1965); shaved back, each rabbit tested on intact and abraded skin, occlusive dressing removed after 24 hours, observations at 24 and 72 hours.

Results: No erythema or edema on intact or abraded skin in any of the 6 rabbits.

Reference: Ciba-Geigy Pharmaceuticals Division, 1983b

Additional Studies:

Other studies, reported in less detail, also reported no effects in rabbits from dermal exposure on intact skin to the dry powdered TPP, and only slight dryness during repeated application as a saturated solution in ethanol (13 times in 16 days) (Dow Biochemical Research, 1933).

Skin Sensitization (OPPTS Harmonized Guideline 870.2600; OECD Guideline 429)

Conclusion:

The available skin sensitization data were judged adequate to meet the endpoint.

Basis for Conclusion:

A confidential skin sensitization study with negative results in guinea pigs was submitted. These data allow this endpoint to be adequately characterized.

No experimental studies of skin sensitization in animals were located in the published literature. A few human cases of TPP allergic dermatitis have been reported. An example is a case of allergy to TPP from cellulose acetate eyeglass frames that contained TPP as an additive (Carlsen et al., 1986). Patch testing of dermatological patients, however, has not generally implicated this chemical as a sensitizer. For example, of 343 patients tested because of suspected sensitivity to plastics and glues components, none reacted to TPP (Tarvainen, 1995). In a study of 23,192 patients with eczema who were patch tested with cellulose acetate film containing 7-10% TPP and 4-5 % phthalic acid, positive reactions were observed in only 15 (0.065%) (Hjorth 1964).

SUBCHRONIC TOXICITY

Subchronic Oral Toxicity (28-day, 90-day, or combined with reproductive/developmental)

Conclusion:

The available subchronic oral toxicity data were judged inadequate to meet the endpoint, but an existing unpublished Food and Drug Administration (FDA) study, if provided, could address this data gap.

Basis for Conclusion:

A single 35-day study in rats (Sutton et al., 1960) provides limited relevant information. The study was not adequate to characterize this endpoint because of the small number of rats in each dose group, testing of only one sex, lack of clinical chemistry and histopathology data, and lack of detailed reporting. A set of concurrent approximately 120-day studies performed by FDA investigated general toxicity, reproductive and developmental toxicity, neurotoxicity, and immunotoxicity (Hinton et al., 1987, 1996; Sobotka et al., 1986; Welsh et al., 1987). The general toxicity study, however, was not published, and the associated studies do not report adequate information on the general toxicity of this chemical.

- **Repeated Dose 28-Day Oral Toxicity in Rodents (OPPTS Harmonized Guideline 870.3050; OECD Guideline 407)**

The only relevant available study is a 35-day repeated oral study that does not satisfy the guideline. A summary of the study is as follows:

Type: 35-Day repeated oral

Species, strain, sex, number: Rat, Holtzman, male, 5/dose

Doses: 0, 0.1, and 0.5% in the diet (the 0.1% group received 5% for the first 3 days, but refused to eat, and therefore was switched to a lower dietary concentration)

Purity: Practical Grade Eastman Organic, purity not specified

Vehicle: None; added to diet

Exposure period, frequency: 35 days, daily

Post Exposure Period: 2 weeks

Method: Two rats/group killed at end of 35 days; 3 rats/group observed for 2 week recovery period; body weight, hematology (hemoglobin, cell volume, red and white cell count, and differential), necropsy with organ weights.

Results: Slight depression in body weight gain in high dose group at day 35, but not after 2-week recovery period. Slight but statistically significant increase (Student's t test) in mean relative liver weight in high dose group—not specified whether all 5 rats/group were included in organ weight determinations. No gross abnormalities seen at necropsy. No statistically significant differences in hematological values.

Reference: Sutton et al., 1960

- **90-Day Oral Toxicity in Rodents (OPPTS Harmonized Guideline 870.3100; OECD Guideline 408)**

The only ≥ 90 day subchronic studies of TPP toxicity were specialized studies of reproductive, developmental, neurological, and immunological endpoints in the rat conducted by the FDA (Hinton et al., 1987; Sobotka et al., 1986; Welsh et al., 1987). These studies provide only limited information on other systemic toxicities, and therefore do not satisfy the guideline.

- In the reproductive and developmental toxicity study in the rat, males and females were fed TPP at dietary levels up to 1% for 91 days prior to mating, continuing through mating, and the females were continued on the diet until day 20 of gestation. This study reported no differences in behavior or gross pathology of the treated dams, a slight but significant decrease on day 0 of gestation in the body weight of the dams fed the 1% diets (690 mg/kg/day), a slight but significant increase in food consumption primarily at 0.5 and 0.75% in the diet (not dose-related), and a non-significant decrease in body weight gain (minus the gravid uterus) at day 20 of gestation in dams fed $\geq 0.5\%$ (341 mg/kg/day) (Welsh et al., 1987).
- The neurological study, in which male rats were fed up to 1% TPP in the diet for 4 months, provided no evidence of neurobehavioral effects, but also noted a decrease in body weight gain. The NOAEL and LOAEL for this effect were 0.25% in the diet (161 mg/kg/day) and 0.50% in the diet (345 mg/kg/day) (Sobotka et al., 1986).
- In the immunotoxicity study, in which male and female rats were fed up to 1% TPP in the diet for 4 months, the only effects seen were a decrease in body weight gain at 1.0% (approximately 700 mg/kg/day) in the diet, and non-dose related increases in the relative percentages of α -globulins in treated females and β -globulins in treated males, which were interpreted as a possible sign of liver activity of uncertain toxicological significance (Hinton et al., 1987). Because of the lack of dose-response, these findings may not be indicative of a chemical effect. The NOAEL and LOAEL for decreased body weight gain were 0.75% in the diet (517 mg/kg/day) and 1.0% in the diet (700 mg/kg/day).

Details of these studies are provided in the appropriate sections. These studies are not adequate to fulfill the requirements of the 90-day subchronic oral toxicity guideline.

An associated, concurrent FDA subchronic toxicity study, mentioned in the other FDA reports (Hinton et al., 1987, 1996; Sobotka et al., 1986; Welsh et al., 1987), has not been published. The study has been requested for review.

- **Combined Repeated Dose Toxicity Study with the Reproduction/Developmental Toxicity Screening Test (OPPTS Harmonized Guideline 870.3650; OECD Guideline 422)**

No studies of this type were located.

Subchronic Dermal Toxicity (21/28-day or 90-day)

Conclusion:

The available subchronic dermal toxicity data were judged inadequate to meet the endpoint, unless further information is provided for the available 21-day study.

Basis for Conclusion:

The only study available for this endpoint, a 21-day dermal toxicity study, has a design similar to that of the OPPTS guideline, but the reporting of the study is deficient. Only the text portion of the results was available, but the tables summarizing the data were omitted, as were data regarding the outcome of tests of purity of the TPP. Because it is the only relevant study, more detailed reporting of information from this study is needed if it is to be used to satisfy the endpoint. The study is summarized below.

- **21/28-Day Dermal Toxicity (OPPTS Harmonized Guideline 870.3200 (OECD Guideline 410))**

Type: 21-Day dermal toxicity

Species, strain, sex, number: Rabbit, New Zealand white, 10 males and 10 females/dose

Doses: 0 (vehicle control), 100, and 1,000 mg/kg body weight

Purity: Determined at start and end of test but results not reported

Vehicle: Absolute ethanol

Exposure period, frequency: 21-23 days, 5 days/week

Post Exposure Period: none

Method: Similar to 870.3200 but functional observational battery omitted, number of tissues/organs examined histopathologically was not as extensive, and histopathological examinations were performed on all control and high dose rabbits and “as required” on low dose rabbits. The skin of 5 males and 5 females in each dose group was abraded twice a week; the skin of the other 5 males and 5 females in each group was not. No dressing was used after application of the vehicle or test substance, but collars were used to prevent contact with the material, and the excess was removed after 6 hours.

Results: No treatment-related changes were seen in clinical signs, mortality, body weight, hematology, gross or histopathology, or routine clinical chemistry. Low-dose females had decreased mean thyroid/body weight ratio and increased mean kidney weight. Dose-related depressions in serum, erythrocyte, and brain cholinesterase were observed. The tables summarizing the actual data were omitted from the report.

Reference: Bio/Dynamics, Inc., 1970

- **90-Day Dermal Toxicity (OPPTS Harmonized Guideline 870.3250; OECD Guideline 411)**

No studies of this type were located.

Subchronic Inhalation Toxicity: 90-Day Inhalation Toxicity (OPPTS Harmonized Guideline 870.3465; OECD Guideline 413)

Conclusion:

No available subchronic inhalation toxicity data.

Basis for Conclusion:

No repeated-exposure inhalation toxicity studies were located.

REPRODUCTIVE TOXICITY

Conclusion:

The available reproductive toxicity data were judged inadequate to meet the endpoint.

Basis for Conclusion:

A study of reproduction and development in rats exposed for 91 days prior to mating, and continuing through mating until day 20 of gestation (Welsh et al., 1987) partially characterizes this endpoint, but is not fully adequate. No other data relevant to this endpoint were located.

- **Reproduction/Developmental Toxicity Screening (OPPTS Harmonized Guideline 870.3550; OECD Guideline 421)**

A study of reproduction and development in rats exposed for 91 days prior to mating, and continuing through mating until day 20 of gestation (Welsh et al., 1987) partially satisfies the reproductive screening component of this guideline, but is not fully adequate, primarily because it lacks histopathology of male and female reproductive organs. The study is summarized below under Developmental Toxicity. Findings relevant to reproduction were that there were no significant differences in number of corpora lutea, implants, implantation efficiency, viable fetuses, and number of early or late deaths at dietary levels as high as 1.0% TPP (690 mg/kg/day). Because both sexes were treated, and there were no effects on litter size (as measured by number of viable fetuses), the study provides some evidence that fertility is not affected by TPP in the rat.

- **Combined Repeated Dose Toxicity Study with the Reproduction/Developmental Toxicity Screening Test (OPPTS Harmonized Guideline 870.3650; OECD Guideline 422)**

No studies with this specific design were available.

- **Reproduction and Fertility Effects (OPPTS Harmonized Guideline 870.3800; OECD Guideline 416)**

No studies with this specific design (two-generation reproduction) were available.

DEVELOPMENTAL TOXICITY

Conclusion:

The available developmental toxicity data were judged adequate to meet the endpoint.

Basis for Conclusion:

A study of reproduction and development in rats exposed for 91 days prior to mating, and continuing through mating until day 20 of gestation (Welsh et al., 1987) appears to fulfill the requirements of the Prenatal Developmental Toxicity Study guideline, and is adequate to characterize developmental toxicity. Details of this study are as follows:

- **Prenatal Developmental Toxicity Study (OPPTS Harmonized Guideline 870.3700; OECD Guideline 414)**

Type: Reproductive screen, prenatal developmental toxicity

Species, strain, sex, number: Rat, Sprague-Dawley, 40 males and 40 females/dose

Purity: Commercial grade, Aldrich, 98% pure

Doses: 0, 0.25, 0.50, 0.75, or 1.00% in the diet (0, 166, 341, 516, and 690 mg/kg/day based on food consumption and body weight of pregnant females)

Exposure duration, frequency: Starting at 4 weeks post weaning, males and females exposed for 91 days prior to mating, continuing through mating and, for the dams, through gestation day 20; daily

Method: Body weight, food consumption, clinical signs, and necropsy of dams; uterine contents at day 20 of gestation; fetal weight, crown-rump length, external, visceral, and skeletal abnormalities; extensive statistical analyses.

Results: The body weights of the females fed the 1.0 % diets were slightly but significantly lower than those of controls on day 0 of gestation. During gestation, the dams that consumed TPP in the diet generally consumed slightly more food than controls; but their body weight gains during gestation and the adjusted body weight gain (excluding gravid uterus) at day 20 were not significantly different from controls. No differences in behavior or gross pathology were reported. Fertility (pregnancy rate) was higher in the treated females than in controls, but control fertility was relatively low. No significant differences between treated and control groups were seen for numbers of corpora lutea, implants, implantation efficiency, viable fetuses, or resorptions (total or early or late deaths). Male and female fetuses from the treated groups tended to weigh more than control fetuses, but the differences were minimal (<10% increase in fetal weight), not dose-related, and significant ($p < 0.05$) only for the males in the 0.50 and 1.00% groups (but not the 0.75% group). Significant, slight increases in visceral variations (moderate

hydroureter, enlarged ureter proximal to kidney) were seen in litters of all treated groups, but the increases were not dose-related, and the controls had a relatively high incidence of moderate hydroureter. Given the lack of dose response and uncertain biological significance of the slight fetal changes in this study, the highest dose level (1.0% TPP in the diet, 690 mg/kg/day) may be a NOAEL for fetotoxicity. TPP did not produce teratogenic effects in this study. This study suggests a minimal LOAEL for decreased body weight gain of 1.0% TPP in the diet (690 mg/kg/day) for the dams. Although the highest dose in the study (1.0% in the diet, 690 mg/kg/day) is not as high as a limit dose of 1,000 mg/kg/day, it did produce slight body weight depression in the dams, and in the two associated studies (on neurotoxicity and immunotoxicity), produced more striking depressions in body weight gain in male and female rats at the same dietary level, particularly in the first few weeks on test, and in the absence of a depression in food consumption. A higher dietary level (5%) was tested in a 35-day study in rats and resulted in food refusal (Sutton et al., 1960). Thus testing with dietary levels substantially higher than 1.0% TPP may not be advisable.

Reference: Welsh et al., 1987

- **Combined Repeated Dose Toxicity Study with the Reproduction/Developmental Toxicity Screening Test (OPPTS Harmonized Guideline 870.3650; OECD Guideline 422)**

No studies with this specific design were available.

- **Reproduction/Developmental Toxicity Screening (OPPTS Harmonized Guideline 870.3550; OECD Guideline 421)**

A study of reproduction and developmental toxicity is available (Welsh et al., 1987); the developmental toxicity portion of the study is consistent with a full prenatal developmental toxicity study, and was discussed previously under that category.

CHRONIC TOXICITY

Conclusion:

No available chronic toxicity data.

Basis for Conclusion:

No relevant studies were located.

- **Chronic Toxicity (OPPTS Harmonized Guideline 870.4100; OECD Guideline 452)**

No studies of this type were located.

- **Combined Chronic Toxicity/Carcinogenicity (OPPTS Harmonized Guideline 870.4300; OECD Guideline 453)**

No studies of this type were located.

CARCINOGENICITY

Conclusion:

The available carcinogenicity data were judged inadequate to meet the endpoint.

Basis for Conclusion:

The available study, a strain A mouse pulmonary adenoma study, is not a suitable type of study to characterize the potential carcinogenicity of chemicals for chronic oral exposure. The study is summarized below.

Type: Strain A mouse pulmonary adenoma

Species, strain, sex, number: Mouse, strain A/St, 20 males/dose

Identity: Uncertain—reported as triphenyl phosphate, and also as phosphorous acid, triphenyl ester (which is triphenyl phosphite, a different chemical)

Purity: Not reported, Aldrich, reagent grade

Doses: 0 (vehicle control), 20, 40, and 80 mg/kg

Vehicle: Tricaprylin

Route: Intraperitoneal injection

Exposure duration, frequency: 3 injections/week; for 20 mg/kg—18 injections (6 weeks), for 40 mg/kg—3 injections (1 week), for 80 mg/kg—1 injection (the experimental design was to give 24 injections, but fewer injections were given for the “more toxic chemicals”).

Method: 24 weeks after the first injection, the mice were killed and the lungs were examined for surface nodules; a few of the nodules were examined histologically to confirm that they were adenomas; positive controls received urethan; Student t test.

Results: Survival at 24 weeks was 46/50 for controls, 18/20 at 20 mg/kg (18 injections), 3/20 at 40 mg/kg (3 injections), and 12/20 at 80 mg/kg (1 injection). No increase in the number of pulmonary adenomas/mouse was seen.

Reference: Theiss et al., 1977

- **Carcinogenicity (OPPTS Harmonized Guideline 870.4200; OECD Guideline 451)**

No studies of this type were located.

- **Combined Chronic Toxicity/Carcinogenicity (OPPTS Harmonized Guideline 870.4300; OECD Guideline 453)**

No studies of this type were located.

NEUROTOXICITY

Conclusion:

The available neurotoxicity data were judged inadequate to meet the endpoint.

Basis for Conclusion:

Some components of this endpoint—delayed neurotoxicity and neurotoxicity screening (in adult animals)—are satisfied by the existing data, but no study of developmental neurotoxicity has been conducted. This endpoint could be addressed in combination with the reproductive toxicity endpoint. TPP gave negative results in several acute oral delayed neurotoxicity studies in the hen as well as a subcutaneous study in the cat, and also in a subchronic oral neurotoxicity screening study in the rat. Further information is provided in the following subsections.

Delayed Neurotoxicity

Conclusion:

The available delayed neurotoxicity data were judged adequate to meet the endpoint.

Basis for Conclusion:

The available acute delayed neurotoxicity studies in the hen and in the cat (another sensitive species), summarized below, give no evidence of acute cholinergic toxicity or of delayed neurotoxicity. These studies, performed prior to the existence of the guidelines, do not entirely conform to the guidelines, and lack detail including, in the hen studies, purity of the TPP sample. Nevertheless, together they indicate a lack of delayed neurotoxicity for TPP. Neurotoxic esterase (NTE) assays were not conducted in these studies. In a separate unpublished study, summarized in a review of structure-activity studies, an NTE assay in brain homogenate following a single oral dose of 700 mg/kg TPP (>99% purity) to the hen (Johnson, 1975) gave negative results. This dose is lower than those used in the critical studies of delayed neurotoxicity in hens but given the lack of signs and histopathological evidence for delayed neurotoxicity, additional NTE assays do not appear necessary.

Because of the lack of signs or histopathology indicating delayed neurotoxicity in the acute studies, 28-day studies are not required. In addition, structure-activity studies indicate that TPP would not be expected to cause delayed neurotoxicity (Johnson, 1975).

- **Acute and 28-Day Delayed Neurotoxicity of Organophosphorus Substances (OPPTS Harmonized Guideline 870.6100; OECD Guideline 418, 419)**

Critical Studies

Type: Delayed neurotoxicity

Species, strain, sex, number: Hen, White Leghorn, 9 for TPP

Purity: Not reported, prepared from pure phenol

Doses: 5,000 mg/kg twice daily; thus, 10,000 mg/kg/day

Vehicle: Corn oil

Route: Gavage

Exposure duration, frequency: Twice a day on days 1-3 and 21-23 of the study (6 days of dosing); interval between doses not reported.

Method: Dosing twice daily for 6 days was needed because of the low toxicity of TPP (no lethality at 5 mg/kg, the largest feasible dose). Hens were fasted for 16 hours before dosing (further explanation not provided). Daily observations for deaths and signs of neurotoxicity were conducted from day 1 through day 42, at which time hens were necropsied. Brain, sciatic nerve, and spinal cord were examined histopathologically. Tricresyl phosphate (mixed o-, m-, p-) was tested concurrently.

Results: For TPP, no overt signs of neurotoxicity and no histopathological effects in the nervous tissues were observed (0/9). Although the hens were weighed at 0, 21, and 42 days, no body weight results were presented. Tricresyl phosphate, a known delayed neurotoxicant, resulted in overt signs and histopathological evidence of delayed neurotoxicity in 6/6. Details of the histopathological data were not provided.

Reference: Johannsen et al., 1977

Type: Delayed neurotoxicity

Species, strain, sex, number: Hen, Rhode Island Red x Light Sussex, 2/dose

Purity: Not reported, white flakes

Doses: 2,000, 3,000, 5,000, 8,000, or 12,500 mg/kg

Vehicle: Arachis oil

Route: Gavage

Exposure duration, frequency: Single dose

Method: Hens were not fasted. Post-dosing observation period was 21 days. Daily observations for deaths and signs of neurotoxicity. Necropsy but not histopathology.

Results: No overt signs of neurotoxicity. Necropsy results not mentioned.

Reference: Ciba-Geigy Pharmaceuticals Division, 1980

Type: Delayed neurotoxicity

Species, strain, sex, number: Hen, Rhode Island Red x Light Sussex, 2

Purity: Not reported, white flakes

Doses: 12,000 mg/kg

Vehicle: Arachis oil

Route: Gavage

Exposure duration, frequency: Single dose

Method: Hens were not fasted. Post-dosing observation period was 21 days. Daily observations for deaths and signs of neurotoxicity. Necropsy but not histopathology.

Results: No overt signs of neurotoxicity, and no abnormalities at necropsy.

Reference: Ciba-Geigy Pharmaceuticals Division, 1981a

Type: Delayed neurotoxicity

Species, strain, sex, number: Cat, not further specified, 5

Purity: Zone-refined triphenyl phosphate, purity 99.99%

Doses, number: 400 mg/kg in propylene glycol (2 cats), 700 mg/kg in corn oil (2 cats), and 1,000 mg/kg in corn oil (1 cat)

Vehicle: Propylene glycol (1 cat), corn oil (2 cats)

Route: Subcutaneous injection

Exposure duration, frequency: Single dose

Method: Post-dosing observation period was 4 months. Daily observations for deaths, general behavior, eating, and drinking. Weighed at intervals. Whole blood, plasma, and erythrocyte cholinesterase determined for cats given 700 mg/kg of TPP and their controls. Complete necropsies on cats given 700 mg/kg. Brain stem and spinal cord examined histopathologically in all cats.

Results: All except one on the lowest dose lost weight (due to cessation of eating); the other on the lowest dose lost weight initially and then regained it. These cats had no overt signs of toxicity and were not necropsied or examined further. At 700 mg/kg, the cats stopped eating during the first week after injection, became moribund, and were euthanized. Cholinesterase activities in these cats were similar to those in the controls. No evidence of axonal degeneration, demyelination, or other adverse change was seen in sections from 11 levels of the nervous system extending from cerebral cortex to peripheral nerve in the 700 mg/kg group. The cat that received 1,000 mg/kg became anorexic 1 week after injection and was necropsied at 3 weeks after injection. Sections of this cat's brain stem and spinal cord did not reveal any abnormalities. Actual data were not presented.

Reference: Wills et al., 1979

Additional studies

Additional oral studies at lower doses in the chicken [one at 500 mg/kg in the hen (Aldridge and Barnes, 1961), and another at 1,000 mg/kg in the cockerel (young rooster) (Hine et al., 1956)] also reported no signs of delayed neurotoxicity. Two delayed neurotoxicity studies that reported some axonal lesions in the spinal cord of hens following 5,000 mg/kg/day of TPP (unknown purity) for 5 days are considered invalid because the doses were so high that most of the hens died or were killed in extremis during the study, severe weight loss occurred in the hens, and the same mild axonal lesions were seen in both controls and treated hens (Ciba-Geigy Pharmaceuticals Division, 1982), or because no controls were used (Ciba-Geigy Pharmaceuticals Division, 1981a).

Neurotoxicity (Adult)

Conclusion:

The available adult neurotoxicity data were judged adequate to meet the endpoint.

Basis for Conclusion:

The available study of neurobehavioral effects following subchronic feeding of TPP to rats (Sobotka et al., 1986) predates the guidelines, but fulfills some of the criteria for a Neurotoxicity Screening Battery. It includes some of the observations from the functional observational battery, and a few additional measures (rearing activity, rotorod, negative geotaxis). It does not include neurohistopathological examinations, and testing was conducted in only one sex rather than both sexes as recommended. In other reasonably well-conducted studies of this chemical, however, there is no evidence that one sex is significantly more sensitive than the other or that the chemical is neurotoxic. Structure-activity studies do not indicate neurotoxic potential for TPP (Johnson, 1975). Therefore, the existing study, in context with the other information regarding TPP toxicity, may be adequate to satisfy the adult neurotoxicity component of the neurotoxicity endpoint. The study description follows:

- **Neurotoxicity Screening Battery (OPPTS Harmonized Guideline 870.6200; OECD Guideline 424)**

Type: Neurotoxicity screening, oral

Species, strain, sex, number: Rat, Sprague-Dawley, 10 males/dose

Doses: 0, 0.25, 0.50, 0.75, or 1.0% in the diet; 0, 161, 345, 517, or 711 mg/kg/day

Vehicle: None

Purity: 98% (commercial grade, Aldrich); homogeneity and stability of TPP diets confirmed by gas chromatography

Exposure duration, frequency: 4 months, daily

Method: Observations included food consumption, body weight, in-cage observation for overt signs, open-field exploratory behavior (motor activity and rearing), rotorod, forelimb grip strength, and negative geotaxis. Extensive statistical analysis.

Results: Overt signs and test results for neurobehavioral endpoints were not statistically significantly different in treated versus control rats. Body weight gain, but not food consumption, was statistically and toxicologically significantly lower (>10% decrease) in the 0.5, 0.75, and 1.0% dietary groups than in controls, and there was a negative dose-related linear trend for weight gain. Thus, no LOAEL for neurotoxicity was demonstrated. The NOAEL and LOAEL for effects on body weight gain were 0.25% in the diet (161 mg/kg/day) and 0.50% in the diet (345 mg/kg/day).

Reference: Sobotka et al., 1986

Developmental Neurotoxicity: Developmental Neurotoxicity Study (OPPTS Harmonized Guideline 870.6300)

Conclusion:

No available developmental neurotoxicity data.

Basis for Conclusion:

No studies of this type were located.

Additional neurotoxicity studies:

- Schedule-Controlled Operant Behavior (mouse or rat)
 - OPPTS Harmonized Guideline 870.6500
- Peripheral Nerve Function (rodent)
 - OPPTS Harmonized Guideline 870.6850
- Sensory Evoked Potentials (rat, pigmented strain preferred)
 - OPPTS Harmonized Guideline 870.6855

These studies may be indicated, for example, to follow up neurotoxic signs seen in other studies, or because of structural similarity of the substance to neurotoxicants that affect these endpoints. These studies may be combined with other toxicity studies.

Conclusion: These endpoints do not appear to be applicable to TPP.

Basis for Conclusion: Although there are no studies addressing these endpoints, there are no reliable data for TPP, and no structure-activity considerations, that indicate a need for these follow-up studies.

IMMUNOTOXICITY

Conclusion:

The available immunotoxicity data were judged adequate to meet the endpoint.

Basis for Conclusion:

The potential immunotoxicity of TPP was examined in a subchronic dietary study in rats (Hinton et al., 1987, reprinted as Hinton et al., 1996) which predates the guideline for immunotoxicity. This study appears to satisfy most of the requirements of the guideline, although no positive control was included, and the anti-sheep red blood cell assay is not the currently recommended assay. The study, which was negative for immunotoxicity, is summarized below.

- **Immunotoxicity (OPPTS Harmonized Guideline 870.7800)**

Type: Immunotoxicity, oral subchronic

Species, strain, sex, number: Rat, Sprague-Dawley, 10 males and 10 females/dose

Doses: 0, 0.25, 0.50, 0.75, or 1.00% TPP in the diet; approximately equivalent (based on measured dosages in the related studies by Sobotka et al., 1986 and Welsh et al., 1987) to 0, 163, 343, 517, and 700 mg/kg/day. No positive control.

Purity: Aldich, 98% pure, confirmed by gas chromatography, stable under the experimental conditions of this study

Exposure duration, frequency: 120 days, daily

Method: Observations included body weight, food consumption, midterm and terminal sacrifice, necropsy, spleen and thymus weights, histopathology of spleen, thymus, and mesenteric lymph nodes, immunohistochemical evaluation of B- and T-lymphocyte regions in these tissues, total serum protein and electrophoretic analysis of serum proteins, humoral response to sheep red blood cells (relative antibody titers by hemolytic assay). Extensive statistical analysis.

Results: The only statistically significant effects were a decreased growth rate (>10% difference in body weight) during the first 4 weeks in males and females of the 1.00% dietary group, and non-dose related increases in the relative percentages of α -globulins in treated females and β -globulins in treated males, which were interpreted by the study authors as a possible sign of liver activity but of uncertain toxicological significance. Because of the lack of dose-response, these findings may not be indicative of a chemical effect. This study did not demonstrate a LOAEL for immunotoxicity. The NOAEL and LOAEL for decreased body weight gain were 0.75% in the diet (517 mg/kg/day) and 1.0% in the diet (700 mg/kg/day).

Reference: Hinton et al., 1987

GENOTOXICITY

Conclusion: The available genotoxicity data were judged inadequate to meet the endpoint.

Basis for Conclusion:

Three studies of gene mutation *in vitro* report negative results. These studies, two in bacteria and one in mammalian cells, predate the relevant guidelines, but were conducted in a manner similar to them, and together, characterize the gene mutation *in vitro* endpoint. Studies of chromosomal aberrations were not available, however, and are needed for adequate characterization of the genotoxicity endpoint.

Gene Mutation in Vitro:

- **Bacterial Reverse Mutation test (OPPTS Harmonized Guideline 870.5100; OECD Guideline 471)**

Type: Bacterial reverse mutation

Species, strain: *Salmonella typhimurium* TA98, TA100, TA1535, TA1537

Metabolic activation: Tested with and without Aroclor 1254-induced liver S9 from male Syrian hamsters (10% in S9 mix for all strains and also 50% for TA1535 and TA1537), and male Sprague-Dawley rats (10% for all strains)

Concentrations: 0, 100, 333, 1,000, 3,333, and 10,000 µg/plate. Solvent was 95% ethanol. A precipitate was present in the plates at ≥3,333 ug/plate; tested in triplicate; plus replicate

Purity: 98% +

Method: Preincubation (20 minutes) and plate incorporation (48 hours) at 37°C. Positive controls were 2-aminoanthracene for all strains with S9, and sodium azide (TA1535 and TA100), 9-aminoacridine (TA1537), and 4-nitro-o-phenylenediamine (TA98) in the absence of S9.

Results: No increase over negative control at any concentration; no apparent cytotoxicity; the two highest concentrations tested may have exceeded solubility limits.

Reference: Zeiger et al., 1987

Type: Bacterial reverse mutation

Species, strain: *Salmonella typhimurium* TA98, TA100, TA1535, TA1537, TA1538

Metabolic activation: Tested with and without Aroclor 1254-induced liver S9 from male Sprague-Dawley rats

Concentrations: 0, 10, 100, 500, and 1,000 µg/plate. Solvent was DMSO; tested in triplicate; plus replicate

Purity: No data, white crystals

Method: Plate incorporation, 48 hour incubation at 37°C; apparently only one plate for each concentration. Negative and positive controls.

Results: No increase in revertants over negative control at any concentration; highest concentration reportedly produced some evidence of physiological effect. *Saccharomyces cerevisiae* D4 also tested.

Reference: Litton Bionetics, Inc., 1978a

- **In vitro Mammalian Cell Gene Mutation Test (OPPTS Harmonized Guideline 870.5300; OECD Guideline 476)**

Type: Mammalian Cell Gene Mutation Test: Forward Mutation

Species, strain: Mouse lymphoma L5178Y

Metabolic activation: Tested with and without Aroclor 1254-induced liver S9 from male Sprague-Dawley rats

Concentrations: 0, 3.13 (only without S9), 6.26, 12.5, 25, 50, and 75 (only with S9) µg/plate. Solvent was DMSO; tested in triplicate; plus replicate

Purity: No data, white crystals

Method: Plate incorporation, 48 hour incubation at 37°C. Negative and positive controls (ethylmethanesulfonate without S9; dimethylnitrosamine with S9).

Results: No increase over negative control at any concentration; highest concentration selected during prescreening as a level that reduced growth potential.

Reference: Litton Bionetics, Inc., 1978b

Other

- **Mitotic Gene Conversion in *Saccharomyces cerevisiae* (OPPTS Harmonized Guideline 870.5575)**

Type: Mitotic Gene Conversion

Species, strain: *Saccharomyces cerevisiae* D4

Metabolic activation: Tested with and without Aroclor 1254-induced liver S9 from male Sprague-Dawley rats

Concentrations: 0, 10, 100, 500, and 1,000 µg/plate. Solvent was DMSO

Purity: No data, white crystals

Method: Plate incorporation, 3- to 5-day incubation at 30°C (without S9) or 37°C (with S9). Negative and positive controls

Results: No increase over negative control at any concentration; highest concentration reportedly produced some evidence of physiological effect.

Reference: Litton Bionetics, Inc. 1978a

No studies were available on the genotoxicity of triphenyl phosphate in the following types of tests:

Gene Mutation in Vivo

Chromosomal Aberrations in Vitro

Chromosomal Aberrations in Vivo

DNA Damage and Repair

Ecotoxicity

Acute Toxicity to Fish (OPPTS Harmonized Guideline 850.1075; OECD Guideline 203)

Conclusion:

The available acute fish toxicity data were judged adequate to meet the endpoint.

Basis for Conclusion:

The available acute fish toxicity studies are summarized in Table 1-1. Acute 96-hour toxicity studies in freshwater fish species including rainbow trout, fathead minnows, goldfish, bluegill sunfish, medaka, channel catfish, and carp and in saltwater species including silverside and sheepshead minnow were located. Most of the 96-hour LC50 values reported in the available literature are consistent with each other and ranged from 300 to 1,200 µg/L. One study (Dawson et al., 1977), however, reported substantially higher LC50 values for TPP (95,000 µg/L in silverside and 290,000 µg/L in bluegill). A reason for this discrepancy is not clear. However, the data reported by Dawson et al. (1977) were considered unreliable because the reported LC50 values are approximately 50 to 150 times greater than the solubility limit of TPP (approximately 2,000 µg/L). Also, the results reported by Dawson et al. (1977) are inconsistent with results from multiple other studies.

Overall, the available acute fish toxicity endpoint appears to be satisfied by the currently existing database for the following reasons:

- Studies are available in both cold- and warm-water freshwater species and in marine species;
- Numerous studies are available that reported similar LC50 values; and
- Although most of the available studies used static conditions, the results from the only study located that used flow-through conditions and analytically confirmed the test concentrations are consistent with results from static studies conducted in the same species. These data indicate that use of static exposure conditions produces similar results as flow-through studies.

It should be noted, however, that sufficient detail was not included in many of the study reports to allow for a comprehensive and independent evaluation of data adequacy, most studies used static conditions and did not analytically confirm the test concentrations, and many studies were conducted prior to publication of GLP guidelines.

A summary of the available acute toxicity studies in fish that were located as well as selected deficiencies in the studies is presented in Table 1-1. Studies that were either published in a foreign language or that were not readily available AND that were not critical to the hazard assessment were not retrieved.

Table 1-1. Summary of available acute fish toxicity studies for triphenyl phosphate (115-86-6)^a

Study Reference	Species Tested	96-Hour LC50	Selected Study Design Parameters						Comments on the Data
			Study Type	Concentration Range Tested	No. of Fish/ Conc	Analytical Monitoring	Water Chemistry ^b	Solvent	
Ahrens et al., 1978	Carp	<1,000 µg/L	Static	Not reported	10	No	pH: NR Temp: “room” temp. DO: NR Hardness: NR	Acetone (0.6 mL/L)	The study conduct followed German guidelines. Reporting deficiencies preclude an independent evaluation of data adequacy. LC50 values were not reported. LC100 was 1,000 and 10,000 µg/L with and without acetone, respectively. LC0 without acetone was 5,000 µg/L. LC0 value with acetone was not observed.
Ciba-Geigy, 1981a	Rainbow trout 49 mm; 0.94 g	850 µg/L	Static	5 concentrations; 0.18 to 1,800 µg/L	10	No	pH: 7.7-8.2 Temp: 14.5-15.6°C DO: 5-9 mg/L Hardness: 172 mg/L	Mixture of octanol (>0.004 mL/L), tween (>0.07 mL/L), and ethylene glycol monomethyl ether (>0.02 mL/L)	The study reportedly followed OECD Guideline 203. TPP purity was 100%; loading rate was 0.21 g/L. Only minor reporting deficiencies were noted. Sublethal effects included abnormal swimming behavior and loss of equilibrium at all concentrations tested.

Table 1-1. Summary of available acute fish toxicity studies for triphenyl phosphate (115-86-6)^a

Study Reference	Species Tested	96-Hour LC50	Selected Study Design Parameters						Comments on the Data
			Study Type	Concentration Range Tested	No. of Fish/ Conc	Analytical Monitoring	Water Chemistry ^b	Solvent	
Dawson et al., 1977	Bluegill sunfish	290,000 µg/L Water solubility is approx. 2,000 µg/L	Static	5 concentrations, 125,000 to 560,000 µg/L	Not reported	No	Dilution water was reported to have a pH of 7.6-7.9 and a hardness of 55 mg/L. Target temp. was 23°C for bluegill and 20°C for silverside	Either distilled water or solvent with (reportedly) relatively low toxicity was used. Concentration of solvent, if used, was not reported.	The reported LC50 value from this study is substantially higher than the water solubility of TPP (approx. 2,000 µg/L); therefore, these data are unreliable.
	Silverside	95,000 µg/L Water solubility is approx. 2,000 µg/L	Static	5 concentrations, 75,000 to 560,000 µg/L					
Food and Drug Research Labs, 1979	Rainbow trout	760 µg/L	Static	5 concentrations, 180 to 1,800 µg/L	10	No	pH: 7.2-7.5 Temp: 12°C±1°C DO: 7.8-10 mg/L Hardness: 42 mg/L	Unidentified solvent	Study reportedly followed U.S. EPA (1975) guidelines. Solvent and blank controls were used. Loading rate was 0.15 g/L.

Table 1-1. Summary of available acute fish toxicity studies for triphenyl phosphate (115-86-6)^a

Study Reference	Species Tested	96-Hour LC50	Selected Study Design Parameters						Comments on the Data
			Study Type	Concentration Range Tested	No. of Fish/ Conc	Analytical Monitoring	Water Chemistry ^b	Solvent	
	Fathead minnow	3,800 µg/L Water solubility is approx. 2,000 µg/L	Static	5 concentrations, 1,000 to 10,000 µg/L	10	No	pH: 6.8-7.5 Temp: 20.6±0.6°C DO: 1.3-9.0 mg/L Hardness: 43 mg/L	Unidentified solvent	Dissolved oxygen concentrations decreased over the course of the study to as low as 1.3 mg/L. The LC50 determined from this study was greater than the water solubility of TPP.
Geiger et al., 1986	Fathead minnow (17 mm; 0.071 g)	870 µg/L	Flow-through (14.4x per day)	5 concentrations; 180 to 1,150 µg/L (mean measured)	20	Yes (GLC; 99.8% recovery)	pH: 7.8 Temp: 24.5°C DO: 6.4 mg/L Hardness: 45.6 mg/L Values are averages over the study duration; ranges were not reported	None used; 1.2 mg/L stock solution in glass wool column	Fish were 29 days old at study initiation. Loading rate was 1.4 g/L, and purity was 98%. In the high-dose group, 19/20 fish were dead by the 24-hour observation, and the remaining fish was dead by the 48-hour observation period. Reporting deficiencies included lack of water chemistry parameter values (e.g., pH, dissolved oxygen, temperature) at each concentration (although mean values were given), and a solvent was not used.

Table 1-1. Summary of available acute fish toxicity studies for triphenyl phosphate (115-86-6)^a

Study Reference	Species Tested	96-Hour LC50	Selected Study Design Parameters						Comments on the Data
			Study Type	Concentration Range Tested	No. of Fish/ Conc	Analytical Monitoring	Water Chemistry ^b	Solvent	
Huckins et al., 1991	Bluegill sunfish (0.5-1 g)	780 µg/L	Static	5 concentrations, 500 to 10,000 µg/L with and without addition of 1 g/L soil and clay	10	No	pH: NR Temp: 22°C DO: NR Hardness: NR	Acetone, unspecified concentration	TPP purity was 99%. Selected reporting deficiencies included concentration of solvent used, pH and dissolved oxygen of the test system during the study, and loading rate.
Industrial Bio Test Labs, Inc., 1972	Rainbow trout	Between 100 and 1,000 µg/L	Static	4 concentrations; 100 to 100,000 µg/L	Not reported	No	pH: 7.3-7.9 Temp: 12.2°C DO: 2.9-7.9 mg/L Hardness: NR	Acetone	Very limited information on the study was available. Data were obtained from unpublished EPA submission from TSCATS. Reporting deficiencies preclude an independent evaluation of data adequacy.
	Bluegill sunfish	Between 1000 and 10,000 µg/L Water solubility is approx. 2,000 µg/L	Static	4 concentrations; 100 to 100,000 µg/L	Not reported	No	pH: 7.6-8.2 Temp: 18.6°C DO: 6.9-7.5 mg/L Hardness: NR	Acetone	

Table 1-1. Summary of available acute fish toxicity studies for triphenyl phosphate (115-86-6)^a

Study Reference	Species Tested	96-Hour LC50	Selected Study Design Parameters						Comments on the Data
			Study Type	Concentration Range Tested	No. of Fish/ Conc	Analytical Monitoring	Water Chemistry ^b	Solvent	
Mayer et al., 1981 EG&G Bionomics, 1978a, b	Rainbow trout	400 µg/L	Static	Not reported	10	No	pH: 7.2 Temp: 12±1°C DO: NR Hardness: 272 mg/L	Not reported	Data were obtained from Mayer et al., 1981 and from unpublished data reported in TSCATS. Fish age, weight, and length and loading rate were not reported.
	Fathead minnow	660 µg/L	Static	3 concentrations; 280 to 2200 µg/L	10	No	pH: 6.3-7.5 Temp: 22±1°C DO: 2.5-8.7 mg/L Hardness: 28-44 mg/L	Triethylene glycol (up to 7.5 mL)	Data were obtained from Mayer et al., 1981 and from unpublished data reported in TSCATS. Fish age, weight, and length and loading rate were not reported.
	Sheeps-head minnow	Between 320 and 560 µg/L	Static	5 concentrations; 56 to 560 µg/L	10	No	pH: 7.9-8.1 Temp: 20±1°C DO: 3.8-6.3 mg/L Hardness: NR Salinity: 17 parts per thousand	Acetone	Data were obtained from Mayer et al., 1981 and from unpublished data reported in TSCATS. Fish age, weight, and length and loading rate were not reported.
Mayer and Ellersieck, 1986	Rainbow trout	370 µg/L	Static	Not reported	Not reported	Yes	pH: 7.4 Temp: 12°C DO: NR Hardness: 40 mg/L	Not reported	Results of analytical monitoring were not reported. General methods were reported in the publication that were not necessarily specific for the test on TPP.

Table 1-1. Summary of available acute fish toxicity studies for triphenyl phosphate (115-86-6)^a

Study Reference	Species Tested	96-Hour LC50	Selected Study Design Parameters						Comments on the Data
			Study Type	Concentration Range Tested	No. of Fish/ Conc	Analytical Monitoring	Water Chemistry ^b	Solvent	
	Channel catfish	420 µg/L	Static	Not reported	Not reported	Yes	pH: 7.5 Temp: 22°C DO: NR Hardness: 38 mg/L	Not reported	Results of analytical monitoring were not reported. General methods were reported in the publication that were not necessarily specific for the test on TPP.
	Fathead minnow	1,000 µg/L	Static	Not reported	Not reported	Yes	pH: 7.3 Temp: 22°C DO: NR Hardness: 44 mg/L	Not reported	Results of analytical monitoring were not reported. General methods were reported in the publication that were not necessarily specific for the test on TPP.
Palawski et al., 1983	Rainbow trout (0.11 g; 24 mm)	360 µg/L	Static	3 concentrations; 210, 240, and 290 µg/L	10	No	pH: NR Temp: NR DO: NR Hardness: NR	Not reported	TPP was 99% pure. The study followed U.S. EPA (1975) guidelines. Fry, 12 days past swim-up stage, were tested. An EC50 based on immobility, mortality, and loss of equilibrium of 300 µg/L was also determined from this study.

Table 1-1. Summary of available acute fish toxicity studies for triphenyl phosphate (115-86-6)^a

Study Reference	Species Tested	96-Hour LC50	Selected Study Design Parameters						Comments on the Data
			Study Type	Concentration Range Tested	No. of Fish/ Conc	Analytical Monitoring	Water Chemistry ^b	Solvent	
Sasaki et al., 1981	Goldfish (0.8-2.8 g)	700 µg/L	Static	Not reported	7 to 9	No*	pH: NR Temp: 25°C DO: NR Hardness: NR	Not reported	Neither goldfish nor killifish are recommended species for testing by OECD 203. Reporting deficiencies preclude an independent evaluation of data adequacy. Selected reporting deficiencies included: water chemistry values (pH, hardness, dissolved oxygen), identification of test concentrations, and use of a vehicle to facilitate dissolution. Spine deformation occurred at 1.1 mg/L.
	Killifish (0.1-0.2 g)	1200 µg/L	Static	Not reported	7 to 9	*In a parallel study, ≈70% of TPP was present in water that contained goldfish after 96 hours.			
Sitthichai-kasem., 1978	Rainbow trout sac-fry (0.081 g)	389 µg/L	Static	Control and 180-1000 µg/L	10	No	pH: 7.0-7.2 Temp: 12°C DO: 7.3-8.5 ppm Hardness: 40-48	Acetone	Fish were acclimated before exposure. Moribund and dead fish were counted at 24, 48, 72, and 96 hours.
	Rainbow trout fingerlings (0.75 g)	299 µg/L	Static	Control and 180-1000 µg/L	10	No		Acetone	

^aStudies that were either published in a foreign language or that were not readily AND that were not critical to the hazard assessment were not retrieved.
^bHardness reported as mg/L CaCO₃

Acute Toxicity to Freshwater and Marine/Estuary Invertebrates (OPPTS Harmonized Guidelines 850.1010 and 850.1035; OECD Guideline 202)

Conclusion:

- The available acute freshwater invertebrate toxicity data were judged adequate to meet the endpoint.
- The available acute marine/estuary invertebrate toxicity data were judged inadequate to meet the endpoint.
- Based on the environmental fate of TPP, additional data may be needed on sediment dwelling organisms. Currently available studies, although inadequate to meet the endpoint in this review, indicate that TPP may be toxic to sediment-dwelling organisms.

Basis for Conclusion:

Freshwater Organisms

The available data are summarized in Table 1-2. Four studies in daphnids were located. All studies used static conditions, and none of the available studies analytically confirmed the test concentrations. The reported EC50 values were consistent with each other and ranged from 1,000 to 1,350 µg/L. Sufficient detail was available from three of the four studies located to allow for an independent evaluation of data adequacy. Reporting deficiencies were noted in those three studies that included lack of identity of concentrations tested, TPP purity, concentration of solvent in the test solutions, and water hardness. In the remaining study (Ziegenfuss et al., 1986), even basic study design parameters were not reported. Due to these reporting deficiencies and on study design deficiencies (lack of analytical confirmation of the test concentrations), none of the currently available studies are independently sufficient to be used as the basis to satisfy the acute freshwater invertebrate toxicity endpoint. Collectively, however, the data appear adequate because the four studies that were located reported a narrow range of EC50 values, thus providing confidence in the reported effect levels.

Studies were also located on the toxicity of sediment-dwelling organisms. Two studies using the midge and one study using the scud were located. These studies indicate that sediment-dwelling organisms could be particularly sensitive to the toxicity of TPP. EC50 values ranged from 250 to 1,600 µg/L. All of the studies in sediment-dwelling organisms used static conditions, and none of the studies analytically confirmed the test concentrations. Based on the inconsistencies in the reported toxicity values and the lack of a study that analytically confirmed the test substance concentrations, these data were not judged to be adequate to satisfy the acute toxicity endpoint for sediment-dwelling organisms. Based on the environmental fate of TPP, additional testing on sediment-dwelling organisms may be needed.

In addition, a confidential study for acute toxicity to freshwater aquatic invertebrates was submitted for which study results were consistent (daphnid 48-hour LC50 = 1.2 mg/L) with

those reported in the publicly available literature. The available data were judged adequate to meet this endpoint.

Marine/Estuarine Organisms

One acute toxicity study in mysid shrimp was located (Table 1-2). The study was a 96-hour static study that did not analytically confirm the test concentrations. The dissolved oxygen concentration in this study was <60% of saturation after the 96-hour exposure period. The LC50 from this study was between 180 and 320 µg/L; a discrete LC50 was not calculated. The available data in mysid shrimp do not appear to be adequate to satisfy the marine/estuarine invertebrate toxicity endpoint because only one publically available study was located, and it used static conditions, did not analytically confirm the test concentrations, and dissolved oxygen concentration in this study was below values recommended by standard guidelines. Because only one study was available, and it of questionable reliability, the marine/estuarine invertebrate toxicity endpoint does not appear to be satisfied by existing data.

Table 1-2. Summary of available acute invertebrate toxicity studies on triphenyl phosphate (115-86-6)

Study Reference	Species Tested	EC50 or LC50 (µg/L)	Selected Study Design Parameters						Comments on the Data
			Study Type	Concentration Range Tested	No. of Organisms/ Conc	Analytical Monitoring	Water Chemistry	Solvent	
Ciba-Geigy Ltd., 1981b	Daphnid	48-hour: 1,350	Static	800-3,700 µg/L	20	No	pH: 8.6 DO: 7.0-7.2 mg/L Temp: 20±1°C Hardness: NR	DMF	Although reporting deficiencies were noted, the study conduct appears to be consistent with current standard guidelines. pH and dissolved oxygen were only measured at test termination and only at the lowest and highest test concentrations. TPP purity was not reported.
Food and Drug Research Labs, 1979	Daphnid	48-hour: 1,280	Static	180-3,200 µg/L	20	No	pH: 8.4-8.5 DO: 7.8-9.4 mg/L Temp: 20±0.5°C Hardness: 232 mg/L	Acetone	Although reporting deficiencies exist, the details that were reported appear to be consistent with current guidelines. Key deficiencies included lack of analytical monitoring of the test concentrations. TPP purity was not reported.

Table 1-2. Summary of available acute invertebrate toxicity studies on triphenyl phosphate (115-86-6)

Study Reference	Species Tested	EC50 or LC50 (µg/L)	Selected Study Design Parameters						Comments on the Data
			Study Type	Concentration Range Tested	No. of Organisms/ Conc	Analytical Monitoring	Water Chemistry	Solvent	
Mayer et al., 1981 Analytical Bio Chemistry Labs, 1978	Daphnid	48-hour: 1,000	Static	Not reported	10	No	pH: 7.7-8.0 DO: 7.2-8.7 Temp: 19°C Hardness: <250 mg/L	Ethanol	Only 10 daphnids were exposed to each concentration. Otherwise, the details reported on the study conduct appear to be consistent with current standard guidelines. The concentrations tested were not identified. TPP purity was not reported.
Ziegenfuss et al., 1986	Daphnid	48-hour: 1,000	Static	Not reported	Not reported	No	pH: NR DO: NR Temp: NR Hardness: NR	Not reported	Even basic study design parameters were not available for evaluation.
Huckins et al., 1991	Midge	48-hour: 360	Static	60-1,000 µg/L	10	No	pH: NR DO: NR Temp: 22°C Hardness: NR	Acetone	Study reportedly followed U.S. EPA (1975) guidelines. Results from monitoring water quality parameters were not reported.
Ziegenfuss et al., 1986 Monsanto Env. Science Section, 1982	Midge	48-hour: 1,600	Static	125-2,000 µg/L	10	No	pH: 7.6-8.1 DO: 8.6-9.3 Temp: 21-23°C Hardness: 268-284 mg/L	Unspecified solvent	The NOAEC was 1,000 µg/L. The study followed U.S. EPA (1975) guidelines.

Table 1-2. Summary of available acute invertebrate toxicity studies on triphenyl phosphate (115-86-6)

Study Reference	Species Tested	EC50 or LC50 (µg/L)	Selected Study Design Parameters						Comments on the Data
			Study Type	Concentration Range Tested	No. of Organisms/ Conc	Analytical Monitoring	Water Chemistry	Solvent	
Huckins et al., 1991	Scud	96-hour: 250	Static	10-560 µg/L	Not reported	No	pH: NR DO: NR Temp: 17°C Hardness: NR	Acetone	Study reportedly followed U.S. EPA (1975) guidelines. Reporting deficiencies preclude an independent evaluation of data adequacy.
Mayer et al., 1981 EG&G Bionomics. 1978c	Mysid shrimp	96-hour: >180 and <320	Static	56-560 µg/L	10	No	pH: 7.8-7.9 DO: 43%-56% of saturated Temp: 20±1°C Hardness: NR	Acetone (1 mL)	Dissolved oxygen was <60% of saturation. Standard guidelines indicate that dissolved oxygen concentration remain >60% saturation throughout the study.
Lo and Hsieh, 2000	Golden apple snail	72-hour: 38,200	Static	10-250 µg/L	30	Yes	pH: 7.5 DO: NR Temp: 26°C Hardness: NR	Not reported	Organisms were 35-40 days old at study initiation. Golden apple snail is not a common test organism.

Algal Toxicity (OPPTS Harmonized Guideline 850.5400; OECD Guideline 201)

Conclusion:

The available algal toxicity data were judged tentatively adequate to meet the endpoint, pending the availability of additional information from the studies that were not included in the published articles.

Basis for Conclusion:

Seventy-two-hour static studies in *Selenastrum capricornutum*, *Scenedesmus subspicatus*, *Chlorella vulgaris* (Millington et al., 1988), a 96-hour static study in *Selenastrum capricornutum* (Mayer et al., 1981), and a 22-day study in *Ankistrodesmus falcatus* were located. These data are summarized in Table 1-3. Taken together, these data may be adequate; however, additional information is needed from the studies before they can be used as the basis for satisfying the algal toxicity endpoint.

Millington et al. (1988) conducted a series of 72-hour static studies that were designed to evaluate the influence of various standard test media (OECD, U.S. EPA, and Bold's basal) on the toxicity of triphenyl phosphate to three algal species, *Selenastrum capricornutum*, *Scenedesmus subspicatus*, and *Chlorella vulgaris*. These static studies followed OECD Guideline 201. Five concentrations ranging from 0.05 to 5 mg/L were tested in triplicate cultures. The test concentrations were not analytically confirmed. The resulting 72-hour NOAEC values ranged from 0.1 to 1 mg/L depending on the algal species tested and the test media used. EC50 values were not derived, and raw data were not available to allow for an independent calculation of EC50 values. Overall, the studies appear to have been adequately conducted. Deficiencies in the data included reporting deficiencies (e.g., raw data, water quality values determined during the study, and growth of control replicates), lack of analytical confirmation of the test concentrations, and lack of EC50 determinations. Provided that the missing study details can be obtained and that an EC50 value can be determined, these data appear adequate to satisfy the algal toxicity endpoint.

Mayer et al. (1981) conducted a 96-hour static test in *Selenastrum capricornutum*. Many details from this study were obtained from the unpublished report submitted to EPA (EG&G Bionomics, 1978d). Five concentrations that ranged from 0.6 to 10 mg/L were tested. Test concentrations were not analytically confirmed. An EC50 of 2 mg/L (95% confidence interval of 0.6-4 mg/L) was derived from this study. A clear NOAEC was not established because a 4% decrease in cell number and a 15% decrease in chlorophyll- α concentration was observed at the lowest concentration of 0.6 mg/L. Although the study appears to have been adequately conducted, initial and final cell concentrations of controls or treated cultures were not reported. Provided that these study details can be obtained, the 96-hour EC50 reported in this study appears to be adequate to satisfy the short-term algal toxicity endpoint. It should be noted that the EC50 determined from this study is at the approximate water solubility limit of TPP (2 mg/L). The lack of a clear NOAEC precludes the use of this study as the sole basis to satisfy the

chronic algal toxicity endpoint. However, the low magnitude of the effect observed at 0.6 mg/L in this study appears to be consistent with the NOAEC and LOAEC values reported in the other algal toxicity studies (Mayer et al., 1981; Wong and Chau, 1984).

Wong and Chau (1984) reported a 22-day NOAEC of 0.1 mg/L and a LOAEC of 0.5 mg/L based on algal growth in *Ankistrodesmus falcatus*. Sufficient detail was not reported in this study to allow for an independent evaluation of data adequacy. Virtually no details on the methods or results were reported. The study also reported 4-hour IC50 values based on incorporation of radiolabeled CO₃ as an indication of primary productivity. These IC50 values ranged from 0.2 to 0.5 mg/L in *Ankistrodesmus falcatus*, *Scenedesmus quadricauda*, and Lake Ontario phytoplankton. The 4-hour IC50 values derived from this study were not considered adequate for this hazard assessment because TPP concentrations that caused reductions in primary productivity after 4 hours of exposure did not affect reproduction or growth during a separate 22-day study conducted by the same laboratory. The NOAEC and LOAEC values derived from the 22-day study were considered inadequate to satisfy the chronic algal toxicity endpoint because sufficient detail was not available on the study design or results to allow for an independent evaluation of study adequacy. However, if data are available to demonstrate that the study was adequately conducted, then the data may be sufficient to satisfy the chronic algal toxicity endpoint. Further, if concentration-response data are available to allow for a calculation of a 96-hour EC50, then the data may also be used to support the short-term algal toxicity endpoint.

Taken together, it appears that sufficient data are available to satisfy the algal toxicity endpoint; however, additional information is needed before the currently available data can be considered adequate.

Table 1-3. Summary of available algal toxicity studies for triphenyl phosphate

Study Reference	Species Tested	EC50, NOAEC, and LOAEC	Selected Study Design Parameters					Comments on the Data
			Study Type	Concentration Range Tested	Analytical Monitoring	Water Chemistry	Solvent	
Millington et al., 1988	<i>Selenastrum capricornutum</i>	<p>EC50: NR 72-hour NOAEC: 0.1-1 mg/L* 72-hour LOAEC: 0.5-5 mg/L*</p> <p>*A range of NOAEC and LOAEC values is reported because tests were performed using three different test media, and the toxicity of TPP was influenced by the test media used.</p>	Static	0.05-5 mg/L	No	<p>pH: NR Temp: 22°C DO: NR Hardness: NR</p>	Acetone (<100 uL/L)	The 72-hour LOAEC was between 0.5 and 5 mg/L depending on the test medium. EC50 values were not determined. Test substance purity was not reported.

Table 1-3. Summary of available algal toxicity studies for triphenyl phosphate

Study Reference	Species Tested	EC50, NOAEC, and LOAEC	Selected Study Design Parameters					Comments on the Data
			Study Type	Concentration Range Tested	Analytical Monitoring	Water Chemistry	Solvent	
Millington et al., 1988	<i>Scenedesmus subspicatus</i>	72-hour NOAEC: 0.1-1 mg/L* 72-hour LOAEC: 0.5-5 mg/L. *A range of NOAEC and LOAEC values is reported because tests were performed using three different test media, and the toxicity of TPP was influenced by the test media used.	Static	0.05-5 mg/L	No	pH: NR Temp: 22°C DO: NR Hardness: NR	Acetone (<100 uL/L)	The 72-hour LOAEC was between 0.5 and 5 mg/L depending on the test medium. EC50 values were not determined. Test substance purity was not reported.
Millington et al., 1988	<i>Chlorella vulgaris</i>	72-hour NOAEC: 1 mg/L 72-hour LOAEC: 5 mg/L The toxicity of TPP to <i>Chlorella vulgaris</i> was not affected by test medium.	Static	0.05-5 mg/L	No	pH: NR Temp: 22°C DO: NR Hardness: NR	Acetone (<100 uL/L)	The 72-hour LOAEC was 5 mg/L using three different test mediums. EC50 values were not determined. Test substance purity was not reported.

Table 1-3. Summary of available algal toxicity studies for triphenyl phosphate

Study Reference	Species Tested	EC50, NOAEC, and LOAEC	Selected Study Design Parameters					Comments on the Data
			Study Type	Concentration Range Tested	Analytical Monitoring	Water Chemistry	Solvent	
Mayer et al., 1981 EG&G Bionomics, 1978d	<i>Selenastrum capricornutum</i>	96-hour: 2 mg/L 95% CI: 0.6-4 96-hour LOAEC: 0.6 mg/L 96-hour NOAEC: Not observed	Static	0.6-10 mg/L	No	pH: 7.0-8.2 Temp: 24±1°C DO: NR Hardness: NR	Acetone: 0.05 mL	The methods reportedly followed U.S. EPA, 1971 guidelines. Control growth was not reported. A NOAEC did not appear to be observed because a 15% decrease in chlorophyll α and 4% decrease in cell number was observed after 96 hours at the lowest concentration of 0.6 mg/L. Test substance purity was not reported.

Table 1-3. Summary of available algal toxicity studies for triphenyl phosphate

Study Reference	Species Tested	EC50, NOAEC, and LOAEC	Selected Study Design Parameters					Comments on the Data
			Study Type	Concentration Range Tested	Analytical Monitoring	Water Chemistry	Solvent	
Wong and Chau, 1984	<i>Ankistrodesmus falcatus</i>	22-day NOAEC: 0.1 mg/L 22-day LOAEC: 0.5 mg/L	Static	0.05-5 mg/L	No	pH: NR Temp: NR DO: NR Hardness: NR	5 µL	Use of standard guidelines was not indicated. Duplicate cultures were used. Virtually no study details were included in the published article, precluding an independent evaluation of data adequacy. Growth of <i>A. falcatus</i> was determined spectrophotometrically. Test substance purity was not reported.

Chronic Toxicity to Fish (OPPT Harmonized Guideline 850.1400; OECD Guideline 210)

Conclusion:

- The currently available data were judged adequate to meet the chronic toxicity endpoint for freshwater fish.
- The currently available data were judged inadequate to meet the chronic toxicity endpoint for saltwater fish.

Basis for Conclusion:

Freshwater Fish

A confidential study for chronic toxicity to freshwater fish was submitted. The study results indicated a Fish ChV of 0.140 mg/L. These data were judged adequate to meet this endpoint.

Publicly available data are summarized in Table 1-4. Two chronic studies in fish were located. Both studies were published in Mayer et al. (1981). The study in fathead minnows reported a NOAEC of 87 µg/L and a LOAEC of 230 µg/L. The study used flow-through conditions and analytically confirmed the test concentrations; however, the study is considered invalid due to the large variation in measured concentrations (55-170 µg/L at the NOAEC and 140-390 µg/L at the LOAEC). The study in rainbow trout is considered to be inadequate because the highest concentration tested was 1.4 µg/L, a concentration that did not elicit any effects. Also, the measured concentrations were not given. Therefore, validity of the test could not be independently evaluated.

Saltwater Fish

No chronic toxicity studies in saltwater fish species were located.

Table 1-4. Summary of available chronic fish toxicity studies for triphenyl phosphate (115-86-6)

Study Reference	Species Tested	NOAEC/ LOAEC	Selected Study Design Parameters						Comments on the Data
			Study Type	Concentration Range Tested	No. of Fish/ Conc	Analytical Monitoring	Water Chemistry	Solvent	
Mayer et al., 1981	Rainbow trout	90-day LOAEC: >1.4 µg/L	Flow-through (20 L/hour)	Nominal: 0.22, 0.38, 0.44, 0.64, 0.91, 1.2, and 1.4 µg/L Measured concentrations not reported	NR, but at least 10 based on the number of fish subjected to vertebrae pathology exams.	Yes (mean measured concentrations were within 62% of nominal)	pH: 7.2 Temp: 12±1°C DO: NR Hardness: 272 mg/L	Unidentified solvent at <0.05 mL/L	Measured concentrations were not reported. Endpoints evaluated included mortality, behavior, weight, length, vertebrae pathology, and eye pathology. Test substance purity was not reported.
Mayer et al., 1981 EG&G Bionomics, 1979	Fathead minnow	30-day NOAEC: 87 µg/L LOAEC: 230 µg/L	Flow-through (20 L/hour)	Mean measured: 0, 2.8, 12, 36, 87, and 230 µg/L	60 eggs 40 fry	Yes	pH: 6.8-7.6 Temp: 25±1°C DO: >75% saturation Hardness: 38-44 mg/L	TEG, unspecified concentration	Results based on fry survival; other parameter were not affected by treatment. Measured concentrations varied substantially and ranged from 55 to 170 µg/L at the NOAEL and from 140 to 390 µg/L at the LOAEL. Test substance purity was not reported.

Chronic Toxicity to Aquatic Invertebrates (OPPTS Harmonized Guidelines 850.1300 and 850.1350; OECD Guideline 211)

Conclusion:

No available chronic toxicity data for freshwater or saltwater invertebrates.

Basis for Conclusion:

Freshwater and Saltwater Species

No chronic toxicity studies in freshwater or saltwater invertebrate species were located.

Acute Oral, Acute Dietary, and Reproductive Toxicity in Birds (OPPTS Harmonized Guidelines 850.2100, 850.2200, and 850.2300; OECD Guidelines 205 and 206)

Conclusion:

No available acute oral, acute dietary, and reproduction toxicity data.

Basis for Conclusion:

No toxicity studies in relevant bird species were located.

Earthworm Toxicity (OPPTS Harmonized Guideline 850.6200)

Conclusion:

No available earthworm toxicity data.

Basis for Conclusion:

No toxicity studies in earthworms were located.

Physical/Chemical Properties

Triphenyl phosphate

CAS 115-86-6

MF $C_{18}H_{15}O_4P$

MW 326.29

SMILES c1ccccc1OP(=O)(Oc2ccccc2)Oc3ccccc3

Physical/Chemical Properties

Water Solubility (mg/L):

Conclusion: The available water solubility data are adequate.

Basis for Conclusion: The two best-documented studies, including one that followed an OECD-guideline test, report solubilities of 1.9-2.1 ppm.

Solubility (mg/L)	Reference
Insoluble	Budavari, 2001 (The Merck Index); Lewis, 2000 (Sax's Dangerous Properties of Industrial Materials); Lide and Milne, 1995 (CRC Handbook of Data on Common Organic Compounds); Lewis, 1997 (Hawley's Condensed Chemical Dictionary)
1.90	Saeger et al., 1979 (shake-flask method using Milli-Q purified water); Huckins et al., 1991; SRC, 2004 (PHYSPROP database)
2.1±0.1	Ofstad and Sletten, 1985 (OECD Guideline 105 (column-elution) from a mixture at 25°C)
1.4-1.6	Howard and Deo, 1979 (in buffered distilled water, pH 4.4-9.5 at 21°C)
0.2-0.3	Howard and Deo, 1979 (in filtered lake or river water, pH 7.8-8.2 at 21°C)
0.73	Hollifield, 1979
0.714	Kuhne et al., 1995

Log K_{ow} :

Conclusion: The available log K_{ow} data are adequate.

Basis for Conclusion: A variety of reputable studies report log K_{ow} values in the range of 4.5-4.7.

Log K_{ow}	Reference
4.59	SRC, 2004 (PHYSPROP database); Hansch et al., 1995
3.9	Unpublished data cited in Bengtsson et al., 1986
4.61	Mayer et al., 1981; Huckins et al., 1991

Log K _{ow}	Reference
4.63	Saeger, 1979 (shake-flask method)
4.67	FMC Industrial Chemical Division, 1979 (shake-flask method)
4.58	Ciba-Geigy, Ltd., 1982
4.62	Monsanto Chemical Co., 1982a Monsanto Chemical Co., 1982b

Melting Point:

Conclusion: The available melting point data are adequate.

Basis for Conclusion: Melting point values within the range of 49-52°C are reported in a variety of reputable secondary sources.

Melting Point (°C)	Reference
50	Lewis, 1997 (Hawley's Condensed Chemical Dictionary); SRC, 2004 (PHYSPROP database)
49-50	Budavari, 2001 (The Merck Index); Lewis, 2000 (Sax's Dangerous Properties of Industrial Materials)
50.5	Lide and Milne, 1995 (CRC Handbook of Data on Common Organic Compounds)
50.4	Ciba-Geigy, Ltd., 1982
50-52	Sigma-Aldrich, 2003-2004
49.5-50	Dorby and Keller, 1957

Boiling Point:

Conclusion: The available boiling point data are adequate.

Basis for Conclusion: Most sources report reduced-pressure boiling points of 244-245°C at 10 or 11 torr for triphenyl phosphate. Perry and Green (1984) report a boiling point of 413.5°C at 760 torr, which is consistent with the boiling point extrapolated using the Clausius-Clapeyron Equation and the parameters measured by Dorby and Keller (1957). It has also been reported that triphenyl phosphate decomposes at or near its boiling point (Dorby and Keller, 1957).

Boiling Point (°C/torr)	Reference
245/11	Lewis, 1997 (Hawley's Condensed Chemical Dictionary); SRC, 2004 (PHYSPROP database); Budavari, 2001 (The Merck Index); Lewis, 2000 (Sax's Dangerous Properties of Industrial Materials); Lide and Milne, 1995 (CRC Handbook of Data on Common Organic Compounds)
244/10	Sigma-Aldrich, 2003-2004

Boiling Point (°C/torr)	Reference
413.5/760	Perry and Green, 1984
414/760	Dorby and Keller, 1957 (Extrapolated according to the Clausius-Clapeyron Equation using experimentally-derived parameters: $\text{Log } P(\text{torr}) = -A/T + C$, where T is in Kelvin, A= 4253, C=9.07)
dec. >410	The decomposition temperature was reported in this same paper.

Vapor Pressure (torr):

Conclusion: The available vapor pressure data are adequate.

Basis for Conclusion: Results from the Clausius-Clapeyron equation as measured by Dorby and Keller (1957) are consistent with the vapor pressure data provided in Perry and Green (1984).

Vapor Pressure (torr/°C)	Reference
6.28x10 ⁻⁶ /25 0.90/193.5 8.6/249.8 84.7/322.5 354/379.2	SRC, 2004 (PHYSPROP database, extrapolated); Dorby and Keller, 1957 (Extrapolated according to the Clausius-Clapeyron Equation using experimentally-derived parameters $\text{Log } P(\text{torr}) = -A/T + C$, where T is in Kelvin, A= 4253, C=9.07)
1/193.5	Lewis, 2000 (Sax's Dangerous Properties of Industrial Materials)
1/193.5 5/230.4 10/249.8 20/269.7 40/290.3 60/305.2 100/322.5 200/349.8 400/379.2 760/413.5	Perry and Green, 1984

Odor:

Conclusion: The odor of this compound has been adequately characterized.

Odor	Reference
Odorless	Lewis, 2000 (Sax's Dangerous Properties of Industrial Materials)
Slight aromatic odor resembling phenol Phenol-like odor	HSDB, 2004

Oxidation/Reduction: No data

Oxidation/Reduction Chemical Incompatibility: No data

Flammability:

Conclusion: The flammability (as the flash point) has been adequately characterized.

Basis for Conclusion: Similar values are reported in several reputable secondary sources.

Flash Point	Reference
435°F (223°C)	Sigma-Aldrich, 2003-2004
428°F (220°C)	Lewis, 1997 (Hawley's Condensed Chemical Dictionary)
428°F (cc)	Lewis, 2000 (Sax's Dangerous Properties of Industrial Materials)

Explosivity: No data

Corrosion Characteristics: No data

pH: No data

UV/VIS Absorption:

Conclusion: The UV/VIS absorption of this compound has been adequately characterized.

Basis for Conclusion: Absorption maxima and coefficients are available for this compound in three solvent systems, and are reported in reputable sources.

Wavelength	Absorption Coefficient	Solvent	Reference
268 nm	912	Hexane	Lide and Milne, 1995 (CRC Handbook of Data on Common Organic Compounds)
262 nm	1175	Hexane	Lide and Milne, 1995 (CRC Handbook of Data on Common Organic Compounds)
256 nm	955	Hexane	Lide and Milne, 1995 (CRC Handbook of Data on Common Organic Compounds)
288 nm	7.03×10^3 l/mol-cm	MeOH, KOH	Sadtler Standard Spectra, no date No absorption above 320 nm
237 nm	2.62×10^4 l/mol-cm	MeOH, KOH	Sadtler Standard Spectra, no date No absorption above 320 nm
268.5 nm	2.36×10^3 l/mol-cm	MeOH	Sadtler Standard Spectra, no date No absorption above 290 nm

Wavelength	Absorption Coefficient	Solvent	Reference
273.5 nm	2.36×10^3 l/mol-cm	MeOH, HCl	Sadtler Standard Spectra, no date No absorption above 290 nm
218 nm	1.78×10^4 l/mol-cm	MeOH, HCl	Sadtler Standard Spectra, no date No absorption above 290 nm

Viscosity: No data

Density/Relative Density/Bulk Density:

Conclusion: The density of this compound has been adequately characterized.

Basis for Conclusion: Similar values for density and relative density are available for this material at different temperatures. Bulk density is also reported in a reputable source.

Density	Reference
1.268 g/cc (60°C)	Lewis, 1997 (Hawley's Condensed Chemical Dictionary)
Bulk: 10.5 lb/gal	Lewis, 1997 (Hawley's Condensed Chemical Dictionary)
1.2055 g/cc (50°C)	Lide and Milne, 1995 (CRC Handbook of Data on Common Organic Compounds)
Specific gravity, 25°C: 1.2	Cited from Midwest Research Institute, 1979 in Huckins et al., 1991

Dissociation Constant in Water:

Conclusion: This endpoint is adequately characterized

Basis for Conclusion: TPP is not expected to dissociate under environmentally important conditions.

Henry's Law Constant:

Conclusion: The Henry's Law Constant has been adequately characterized for this compound.

Basis for Conclusion: One measured and one estimated value are reported in the literature, and are in reasonable agreement with one another. The estimated value is based on measured vapor pressure and water solubility data.

Henry's Law Constant	Reference
1.2×10^{-5} atm-m ³ /mole	Cited from Mayer et al., 1981 in Huckins et al., 1991
3.31×10^{-6} atm-m ³ /mole	SRC, 2004 (PHYSPROP database, estimated from vapor pressure and water solubility)

Environmental Fate

Bioconcentration

Fish:

Conclusion: The bioconcentration of TPP has been adequately measured in rainbow trout, goldfish, and killifish.

Basis for Conclusion: Similar BCFs are reported for rainbow trout in two key 90-day studies (Monsanto Chemical Company, 1982c; Mayer, 1981). Other studies (Muir, 1984; Muir et al., 1980) are available, but exhibit significant scatter in the data for rainbow trout. The data reported by this author are based on uptake times of 24 hours or less, and may not represent equilibrium conditions. The highest kinetic BCF value reported by this author, 18,960, may be irrelevant because it was calculated based on a “slow” rate of elimination of residual radioactivity by the fish. According to this study, the fish eliminated 98-99% of the initial load of radioactivity (from the uptake of ^{14}C -labeled TPP) in 9 days. The remaining 1-2% was eliminated more slowly. Because only the total amount of radioactivity was measured without identifying specific radioactive compounds present, it is not certain that the residual radioactivity was due to unchanged TPP and not to metabolites.

Adequate studies are available for goldfish and killifish (Sasaki et al., 1981, 1982). In these two studies, the authors measured BCFs under both static and flow-through conditions, with varying TPP concentrations, and over differing lengths of time. The authors found that the measured BCFs for killifish were largely independent of these parameters.

Reference	Species	BCF	Key Design Parameters				Comments
			Exp. Type	Range (ppb)	Study Length	T (°C)	
Monsanto Chemical Co, 1982c	Rainbow Trout	271			90 days		
Mayer, 1981	Rainbow Trout	132-364	Flow-through	0.22, 1.4	90 days		Elimination half life 0.54 days
Muir, 1984	Rainbow Trout	573 931 1368	Static	3.1-50.4	1-24 hours		

Reference	Species	BCF	Key Design Parameters				Comments
			Exp. Type	Range (ppb)	Study Length	T (°C)	
Muir et al., 1980	Rainbow trout	2,590 (fast) 18,960 (slow)	Static	50	6 hours	10	River water mixed with dechlorinated tap water, pH 8.12-8.36. Fish were exposed to TPP+water for 6 hours then transferred to clean water. BCF expressed as $k(\text{uptake})/k(\text{elimination})$. $k(\text{uptake}) = 46.36/\text{hour}$. Elimination rate slows down at about 9 days with 98-99% eliminated. $k(\text{fast})=0.0179/\text{hour}$; $k(\text{slow})=0.00245/\text{hour}$.
Muir, 1984	Fathead minnow	218 561 1,743	Static	0.8-34.9	1-24 hours		
Sasaki et al., 1981	Killifish	250-500	Static	250 initial	2-3 days	25	
Sasaki et al., 1981	Goldfish	110-150	Static	250 initial	2-3 days	25	
Sasaki et al., 1982	Killifish	189±90 193±79 84±32	Flow-through (all)	30 20 10	35 days 32 days 18 days	25	BCF is independent of concentration, continuous (flow-through) results correlate to static results (Sasaki, 1981). BCF of phosphate esters tested correlate with $\text{Log } K_{ow}$.

Daphnids: No data

Green Algae: No data

Oysters: No data

Earthworms: No data

Fish Metabolism:

Conclusion: The metabolism rate in fish has not been adequately characterized, and the metabolites have not been adequately identified.

Basis for Conclusion: None of the studies summarized here identifies any metabolites. All of the studies were designed to monitor the levels of TPP (as either the natural isotope or ^{14}C labeled) in fish to document the rates of uptake and elimination. Although these studies provide information about the rate of elimination of TPP and/or its carbon-containing metabolites from fish, none of these studies adequately describe how TPP is metabolized and what products are formed.

Species	Rate	Comment	References
Rainbow trout	98-99% eliminated in 9 days Rate constant = 0.0179/hour Slower elimination after 9 days Rate constant = 0.00245/hour		Muir et al., 1980
Rainbow trout	Elimination half-life is 0.54 days		Mayer et al, 1981
Killifish	Elimination half-life 1-2 hours		Sasaki et al., 1982
Killifish	Apparent metabolism is much faster in killifish than in goldfish.	Concentration of TPP in water decreased in the presence of fish. 0% applied TPP remains in the water after ~72 hours. Control (no fish) has no change in TPP concentration.	Sasaki et al., 1981
Goldfish	Apparent metabolism is much slower than in killifish.	60-65% applied TPP remains in the water after 100 hours in presence of goldfish.	Sasaki et al., 1981

Degradation and Transport

Photolysis in the Atmosphere: No data

Photolysis in water:

Conclusion: The available studies do not adequately describe the photolysis behavior of TPP in water under normal environmental conditions. However, this endpoint appears to be adequately characterized.

Basis for Conclusion: Since triphenyl phosphate does not absorb light at wavelengths above 290 nm, direct photolysis in sunlight is not expected. Three published photolysis studies were located. Similar rate constants and half-lives are reported. For two of these studies, the light

from the lamps was not filtered to block wavelengths <290 nm in either experiment (Hg lamps emit at 254 nm), and the results are not environmentally relevant. For the third, the rate constant for photolysis was found to be 34 times greater than phenol with a quantum yield of 0.290 at 254 nm (Wan et al., 1994).

Photolysis of Aqueous Triphenyl Phosphate Irradiated with Low-Pressure Hg Lamps		
Initial concentration: 0.1 ppm pH: 3 and 10	Pseudo 1 st -order rate constant was >40/hour ($t_{1/2}$ <1.04 minutes) at both pH levels. Some hydrolysis may occur at pH 10	Ishikawa et al., 1992
Initial concentration: 3.0×10^{-4} M pH: 3.4 Time: 6 hours	TPP removed: 100% PO_4^{3-} detected: 60% of theoretical max. Phenol detected: 0%	Ishikawa et al., 1992
Initial concentration: 3.0×10^{-4} M pH: 12 Time: 6 hours	TPP removed: 100% PO_4^{3-} detected: 60% of theoretical max. Phenol detected: 9% of theoretical max.	Ishikawa et al., 1992
Initial concentration: 1.0 ppm	Rate constant: 1.9×10^{-2} /second Half-life: 0.6 minutes	Hicke and Thiemann, 1987

Photolysis in Soil: No data

Aerobic Biodegradation:

Conclusion: The biodegradation of TPP under aerobic conditions has been adequately characterized.

Basis for Conclusion: The key study was performed according to OECD guidelines. Additional studies are available, in which TPP is degraded under a variety of conditions. TPP was also found to be readily biodegradable in experimental studies.

Study Type/ Method	Innoculum	Acclim.	Degradation	Time	Comments	Reference
OECD 303A	Activated sludge	14 days	93.8% as DOC removal	20 days	Initial concentration 5 ppm, emulsified with octanol	Ciba-Geigy, Ltd., 1983
SCAS	Activated sludge		>95%	24 hours		Monsanto Chemical Co., 1980
River die-away			50%	2-4 days		Monsanto Chemical Co., 1980

Study Type/ Method	Innoculum	Acclim.	Degradation	Time	Comments	Reference
CO ₂ evolution	Activated sludge	14 days	82%	27 days	Initial concentration 22 ppm	Mayer et al., 1981
CO ₂ evolution	Activated sludge	14 days	61.9% 81.8%	7 days 28 days	Initial concentration 18.3 ppm	Saeger et al., 1979
Simulated biological treatment/ SCAS	Activated sludge w/ domestic sewage feed		95%	24 hours		Mayer et al., 1981
Simulated biological treatment/ SCAS	Activated sludge w/ domestic sewage feed		93-96%	24 hours	12-week test duration, acclimation time not reported	Saeger et al., 1979
River die-away	River/lake water	20-day lag time	100% as TPP removal by GC analysis	7-8 days	Seneca River water pH 8.2, Lake Onondaga water pH 7.8, Lake Ontario water pH 8.2, all NY sources; hydrolysis may interfere with measurement at higher pH	Howard and Deo, 1979
River die-away	Mississippi River water		50% primary biodegradation	2-4 days	Initial concentration 0.05 ppm	Mayer et al., 1981
River die-away	Mississippi River water		100%	1.75 days	Initial concentration 1.0 ppm	Saeger et al., 1979
MITI II	Sewage sludge		83-94%	28 days		Chemicals Inspection & Testing Institute, 1992

Anaerobic Biodegradation: No data

Porous Pot Test: No data

Pyrolysis:

Conclusion: The pyrolysis products of triphenyl phosphate have not been adequately described.

Basis for Conclusion: No formal pyrolysis studies have been located in the literature.

Pyrolysis Products	Reference
Products include phosphorous oxide	Lewis, 2000 (Sax's Dangerous Properties of Industrial Materials)

Hydrolysis as a Function of pH:

Conclusion: The hydrolysis data are adequate.

Basis for Conclusion: Triphenyl phosphate is rapidly hydrolyzed at high pHs, more slowly hydrolyzed at neutral pH, and only very slowly hydrolyzed at acidic pHs. The rates measured under alkaline conditions (pH ~9) are in good agreement with one another, and the rates measured under acidic conditions (pH ~5 or lower) are in reasonable agreement with one another. The results for hydrolysis at pH 7 have been reported to be 19 days, 1.3 years, and 406 days. There is no apparent reason for this discrepancy in values. It appears that the half-life of 19 days was measured once (Mayer et al., 1981) and has then been repeated in other sources. The longer half-life (ca. 1.3 years) has been reported (within acceptable experimental error) in two independent studies (Mabey and Mill, 1978), and is consistent with the observation in Howard and Deo (1979) that the half-life at pH 6.7 was too slow for accurate measurement over the course of the study (14 days).

T _{1/2}	pH	Temp.	Comment	Reference
19 days 3 days	7 9	25°C		Mayer et al., 1981
7.5 days 1.3 days	8.2 9.5	21°C	Half-life was too slow for accurate measurement at pH 4.5 and 6.7. Diphenyl phosphate was the only hydrolysis product identified	Howard and Deo, 1979
1.3 years	7	25°C	Rate constant = 1.7×10^{-9} /sec at pH 7	Mabey and Mill, 1978
>28 days 19 days 3 days	5 7 9			Monsanto Chemical Co., 1980
366 days 406 days <5 days	3 7 9	20°C		Ciba-Geigy, Ltd., 1984
630 days 1,125 days <10 days	3 7 9	10°C		Ciba-Geigy, Ltd., 1984
28 days 19 days 3 days	5 7 9	25°C		Mayer et al., 1981, cited in Anderson et al., 1993

Sediment/Water Biodegradation:

Conclusion: The biodegradation of triphenyl phosphate in the presence of pond and/or river sediment under various conditions has been adequately characterized.

Basis for Conclusion: Biodegradation of TPP has been studied under a variety of conditions and temperatures in the presence of both river and pond sediment.

Sediment	Temp.	T _{1/2}	Comments	Reference
Pond soil	25	50-60 days	Aerobic conditions. Sediment is described to be hydrosol from a small pond. Initial concentration, 0.05 ppm Major product is diphenyl phosphate.	Muir et al., 1989
Pond sediment	25 10 2	2.8 days 2.8 days 11.9 days	Static conditions (air/oxygen neither excluded nor added during the test). Sediment was collected from a eutrophic farm pond near Winnipeg, Manitoba. Initial TPP concentration 0.10 µg/mL. Sediment:water ratio 1:10.	Muir et al., 1989
River sediment	25	7.0 days	Static conditions (air/oxygen neither excluded nor added during the test). Sediment was collected from the Red River near Winnipeg, Manitoba. Initial TPP concentration 0.10 µg/mL. Sediment:water ratio 1:10.	Muir et al., 1989
Pond sediment	25	56.7%, 3 days* 13.1%, 40 days*	Aerobic conditions (respirometer, aerated). Initial TPP concentration 0.05 µg/mL Sediment:water ratio 1:20 *Half-life not reported. Values are % TPP remaining over time.	Muir et al., 1989
River sediment	25	68.9%, 3 days* 10.3%, 40 days*	Anaerobic conditions (respirometer, under N ₂). Initial TPP concentration 0.05 µg/mL Sediment:water ratio 1:20 *Half-life not reported. Values are % TPP remaining over time.	Muir et al., 1989

Soil Biodegradation with Product Identification:

Conclusion: The biodegradation rate of triphenyl phosphate in soil has been adequately characterized under aerobic and anaerobic conditions. The biodegradation products have been adequately characterized.

Biodegradation of Triphenyl Phosphate in a Loamy Sand Soil at 20°C					
Conditions	Percent TPP Remaining Over Time, HPLC				Metabolites Identified
	13 Days	32 Days	60 Days	101 Days	
Aerobic	69.3	46.6	30.4	20.2	Diphenyl phosphate, CO ₂
Anaerobic		50.2	35.4	31.4	Diphenyl phosphate, CO ₂ , phenol
Reference: Anderson et al., 1993					

Indirect Photolysis in Water: No data

Sediment/Soil Adsorption/Desorption:

Conclusion: The K_{oc} has been adequately characterized in a variety of soil types.

K _{oc}	Soil Type	Reference
2514	silty clay	Anderson et al., 1993 All measurements were made at 20°C.
3561	loamy sand	
2756	silt loam	

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